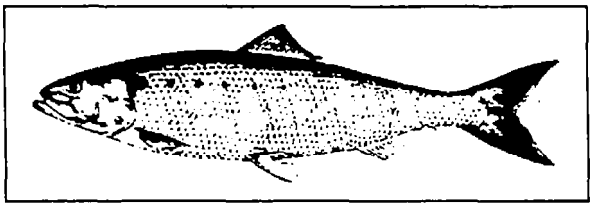
◆ AMERICAN SHAD



INTRODUCTION

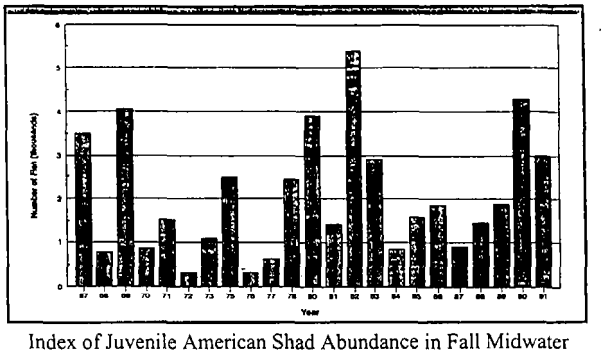
American shad is an important non-native anadromous sport fish with high recreational value. It migrates in spring from the ocean into the Bay-Delta and upstream to spawn in Central Valley rivers. Newly hatched young spend their first summer in the rivers and Delta before migrating downstream to the ocean in fall.

Major factors that limit the contribution of the American shad to the health of the Delta are streamflow, aquatic habitat, and food supply.

RESOURCE DESCRIPTION

The American shad was introduced into Central Valley rivers from the east coast in the 1870s and 1880s. It adapted well to the complex habitat conditions of the rivers and estuary. It continues to be an important sport fish in the Sacramento, Feather, Yuba, and American rivers and has extended its range as far north as the Columbia River. Adults (age 3-5) migrate into the rivers from the ocean to spawn from late April through June. Some may remain in the rivers through August before returning to the Bay-Delta and ocean. Many die during the spawning run, but about 30% of the runs are made up of repeat spawners. In the Sacramento River system, American shad are commonly found from Red Bluff downstream to the Delta and in the lower Feather, Yuba, and American rivers. American shad populations are small in the San Joaquin basin compared with those in the Sacramento basin.

When the adult population was measured in 1976 and 1977, the total Central Valley run was estimated at 3 million and 2.8 million, respectively. The California Department of Fish and Game (DFG) has conducted annual fall midwater trawl surveys in the Delta since 1967 to monitor trends in the population's health. Juvenile shad catch has generally been higher in wetter years (1967, 1969, 1975, 1978, 1980, 1982, and 1983) and lower in dry years (1968, 1972, 1976, 1977, 1984, and 1987). The production index was relatively high, however, in two recent dry years (1990 and 1991).



Index of Juvenile American Shad Abundance in Fall Midwater Trawl Survey

Ocean, estuary, and river conditions affect overall shad abundance. Growth and survival in the ocean may be affected by El Niño (ocean warming). Water temperatures and flows are important habitat factors in the spawning rivers of the Central Valley. River flows trigger the shad to move into rivers and affect their selection of spawning locations among and within the rivers. Water temperatures determine the onset of spawning (59-68°F). High water temperatures (above 68°F) may reduce adult survival. Factors believed to affect American shad production in the Central Valley include the following:

- Low flows in spring may delay or hinder shad from moving into the rivers to spawn. During their upstream migration through the Delta, adult shad may delay spawning or may die because of the higher water temperatures resulting from low flows. Low flows also may reduce downstream transport of eggs and larvae to productive nursery areas.
- Transport of Sacramento River water south across the Delta and toward the south Delta pumping plants may carry more American shad young into the southern Delta and away from their primary migration path to the ocean. Under low Delta outflow, shad young may be more susceptible to loss at agricultural diversions

and water project export pumps. Annual losses of juveniles at south Delta export facilities reach into the millions.

- Poor water quality and low spring flows may limit production of American shad in the San Joaquin River and its tributaries.
- Diversion dams on valley rivers limit American shad from moving into potential spawning reaches. Examples include the Red Bluff Diversion Dam on the Sacramento River, Daguerre Dam on the Yuba River, and Woodbridge Dam on the Mokelumne River. Shad are generally unable to use the fish ladders provided at these diversion dams.
- Pollutants may affect the production and run size of American shad by reducing survival of young and their food supply.

Harvest rates of adult shad in the sport fishery are low and have little impact on production of American shad.

VISION

The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s.

Achieving this vision will reduce the conflict between protection of this species and other beneficial uses of water in the Bay-Delta.

A major focus of Central Valley fish recovery efforts over the past two decades has been on flow enhancement in streams and rivers. Natural river flows in dry and normal water-year types has been reduced, particularly in spring, by water development in the Central Valley. The 1995 December Delta Accord provided interim provisions for improving spring flows. Further improvements are anticipated under the Central Valley Project Improvement Act (CVPIA).

The restoration of American shad vision requires further improvements in drier years when more flow is needed to attract American shad to upstream spawning areas in the rivers and major tributaries, including the American, Feather, and Yuba rivers, and to transport egg and larval shad to nursery grounds in the lower rivers and Delta.

Habitat improvements could contribute to increases in American shad runs. Protecting, improving, and restoring shallow-water habitat in rivers and the Delta may improve the food supply for American shad and provide better rearing habitat. Improved food supply and rearing habitat may help to overcome other factors that are unlikely to change (e.g., the presence of competing non-native species).

Reducing the extent and effect of stressors will further benefit American shad runs. Most important will be reducing loss of young American shad at water diversions in rivers and the Delta, especially large losses at the south Delta pumping plants of the State and federal water projects. The two fish protection facilities should be upgraded to reduce entrainment of young American shad in the pumping plants and the concentrations of predators associated with the fish protection facilities. Screening or reducing the number of the many small water diversions to agricultural lands in the Delta may also provide benefits. Limiting further introduction of non-native species and reducing the input of toxic pollutants into Central Valley waterways will also provide benefits.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain American shad runs in Central Valley rivers would involve cooperation and support from other established programs underway to restore American shad and other important fish.

- CVPIA (PL 102-575) calls for doubling the American shad population by 2002 through changes in flows and project facilities and operations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 DFG is required under State legislation to restore American shad in the Central Valley.
- The Lower American River Task Force and Water Forum will improve flows and habitat in the lower American River that will benefit American shad.

- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Actions to restore populations of salmon, steelhead, striped bass, and Delta native fishes are likely to benefit the runs of American shad.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: The target for American shad is to maintain production of young as measured in the fall midwater trawl survey and targets of the Anadromous Fish Restoration Program (US Fish and Wildlife Service 1997, in preparation). Specifically, the index of young American shad production should increase, especially in dry water years.

LONG-TERM OBJECTIVE: Allow American shad numbers (and harvest) to increase gradually as conditions in the restored estuary and streams favor its reproduction and survival. Use harvest and other management measures to ensure that increases in American shad populations do not jeopardize programs to sustain native species.

SHORT-TERM OBJECTIVE: Maintain the fishery for American shad at its present levels but without special intervention (e.g. special flow releases).

RATIONALE: The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: No special efforts to increase American shad numbers will have been made and benefits to shad will have been derived from restoration actions directed to other species such as chinook salmon. Their impact on juvenile salmon (predation) in the Sacramento River will have been investigated.

RESTORATION ACTIONS

The general target for American shad is to improve production of young, particularly in dry years as measured in the DFG fall mid-water trawl survey.

Programmatic actions that would help improve American shad populations in Central Valley rivers include the following:

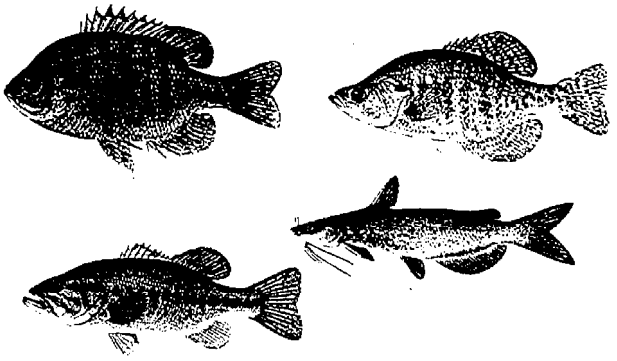
- Provide additional Sacramento, Feather, Yuba, and American river flows in spring of dry and normal water years to attract adult spawners and transport young downstream to productive nursery habitat.
- Remove barriers to American shad migrations in the Sacramento, Yuba, and Mokelumne rivers.
- Reduce adverse effects of water diversions on American shad in fall.
- Allow the first natural pulse of flow in the fall to pass through the Delta to the Bay to help juvenile American shad migrate to the ocean.
- Upgrade existing fish protection facilities at south Delta pumping plants of the Central Valley Project and the State Water Project.

- Reduce the number, screen or upgrade screening, or relocate diversions that entrain American shad in the rivers and Bay-Delta.

REFERENCE

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ NON-NATIVE WARMWATER GAMEFISH



INTRODUCTION

Throughout the Sacramento-San Joaquin Delta warmwater gamefish are an important component of resource health. Not only do these species fill an important biological component, they are also of economic importance. The group of warmwater gamefish is represented by largemouth bass, white crappie, bluegill, redear, green sunfish, white and channel catfish, brown and black bullhead and striped bass to name a few. The warmwater gamefish group is best represented by both the largemouth bass (*Micropterus salmoides*) and white catfish (*Ameiurus catus*). Within the Delta over forty largemouth bass fishing tournaments are held yearly. Currently, largemouth bass populations support a 30 percent catch and release fishery in the Delta, while the white catfish has a harvest rate of around 10% to 15%.

Factors that may limit the warmwater gamefishes ability to contribute to a healthy Delta ecosystem is the degradation and loss of existing aquatic habitat as a result of channel dredging, levee stabilization, and increased channel velocities.

RESOURCE DESCRIPTION

The largemouth bass was first introduced into California waters in 1870s and has since spread to suitable habitats throughout the State. The largemouth bass prefers warm, slow moving waters with low turbidity. Within the Delta the largemouth bass tends to inhabit sloughs and backwaters with large quantities of aquatic cover and submerged objects. The overall stability and health of the largemouth bass population in the Delta is at an all time high. The healthier population (related to size of the fish) of fish is due to the introduction of the "Florida strain" to the gene pool.

Spawning for largemouth bass occurs in the second or third year of life when water temperatures reach 14 to 16 degrees C in April and continues through June. Nests are shallow substrate depressions located in about one to two meters of water near submerged objects. Eggs are adhesive and hatch within two to five days after being fertilized. The nest and eggs are actively protected by the male until sac-fry emerge from nest in about five to eight days.

The white catfish was first introduced into the San Joaquin River in the mid-1870s and has since been introduced into all of the major water systems of the State (except the Colorado and Klamath systems). The white catfish prefers slow moving waters in channels devoid of heavy aquatic vegetation and is typically found in waters greater than two meters deep. The overall interest in white catfish as a gamefish is due to the fact that it is quite numerous within the Sacramento-San Joaquin Delta.

Spawning age and size for white catfish is highly variable and occurs from April through June. Nest sites are typically located in cave-like structures, like muskrat burrows, log jams, and undercut banks. Spawning activity is also triggered by water temperatures when they approach 21 to 29 degrees C, with optimum spawning occurring at 27 to 28 degrees C. The nest is actively guarded by the male. The eggs hatch in about six to ten days with the young actively swimming about two days after hatching.

Losses to Delta diversions (e.g., hundreds of small agricultural diversions, Central Valley Project and State Water Project export pumps, and Pacific Gas & Electric power generation facilities) may reduce resident species abundance through direct entrainment or indirect effects on the prey of resident fish. Large numbers of some resident species (e.g., white catfish, threadfin shad) are entrained in Delta diversions. Other resident species (e.g., largemouth bass) spend their lives in habitat that is in close proximity to where they were spawned and are not particularly susceptible to entrainment in Delta.

Food availability, toxic substances, and competition and predation are among the factors influencing abundance of resident species. In addition, harvest of many resident species for food and bait by sport anglers may affect abundance.

VISION

The vision for warmwater gamefish is to maintain self-sustaining populations in order to provide opportunities for consumptive use such as fishing.

Increasing the variability in aquatic habitat types would provide additional spawning, nesting, rearing, and escape cover for all species of fish, both game and non-game species. Population levels and harvest/catch rates for all gamefish species will need to be monitored to determine restoration success.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain and enhance the population of warmwater gamefish in the Sacramento-San Joaquin Delta would also involve cooperation and support from other established programs.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes.
- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.
- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.
- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.
- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and maintenance of warmwater gamefish populations and habitats will benefit from other CALFED actions to increase flows, enhance levees, establishing riparian corridors, and increase the productivity of the food web.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

SPECIES TARGET: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

LONG-TERM OBJECTIVE: Non-native warmwater game fishes will continue to be abundant enough in many parts of the estuary and river systems to support a substantial sport fishery.

SHORT-TERM OBJECTIVE: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

RATIONALE: White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of

the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.

STAGE 1 EXPECTATIONS: Studies will have been conducted to find out how major CALFED actions are likely to affect the warmwater fish and fisheries and how the fishes affect the recovery of native at-risk species. In particular, the potential of the non-native fishes to use and dominate newly created warmwater habitat will have been thoroughly investigated.

RESTORATION ACTIONS

Warmwater gamefish would benefit from the following actions and restorations: activities:

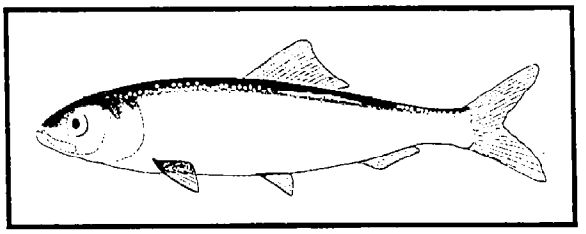
- acquire and enhance aquatic habitat,
- creation of tidally influenced fresh-water woodlands,
- creation of set-back levees to increase shallow-water habitat along existing channels,
- eliminate water hyacinth and other noxious aquatic plants from the Delta,
- update existing fish protection facilities at the South Delta pumping plants,
- installing screens on unscreened diversions, and
- preventing further introductions of non-native aquatic organisms.

REFERENCES

Moyle, P. B. 1976. Inland Fishes of California. University of California Press, Berkeley. pps 242-244, 313-316.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

◆ PACIFIC HERRING



INTRODUCTION

California's largest population of Pacific herring uses San Francisco Bay as a spawning and nursery grounds. This population supports a multi-million dollar a year commercial fishery for roe which is exported to Japan. The herring fishery is the best monitored fishery in California and over-exploitation of the commercial fishery is not expected to occur. Herring are also an important component of the Bay's food web for other fish, birds, mammals, and invertebrates.

The primary factor affecting the year-class strength of Pacific herring is the Bay and ocean nutrient productivity.

RESOURCE DESCRIPTION

Pacific herring inhabit areas along the Pacific coast of the North American continent. Typically adult herring reside in the ocean and return to the Bay during the November through March spawning season. However, juveniles (young of the year) have been noted in the estuary year round. Spawning activities primarily occur in the intertidal and shallow subtidal zones on a variety of substrates, including pilings, rocks, jetties, eelgrass, and seaweed.

Spawning occurs from October through April in San Francisco Bay with peak activity occurring in January. The eggs are adhesive and stick to structures or substrates and hatch in about ten days, depending on temperature.

VISION

The vision for the Pacific herring is to maintain a self-sustaining populations in order to support commercial fishing.

The Pacific herring is also an integral part of the Bay food web. A major focus of efforts to maintain the fishery would be to assure that shallow intertidal zones with aquatic vegetation are protected and enhanced. CALFED will also need to assure that salinity regimes of the Bay and surrounding areas are maintained during spawning and juvenile periods. Some of the activities scheduled for implementation during Stage 1 Actions will benefit the Pacific herring.

Current efforts by the Department of Fish and Game to monitor the herring population and commercial fishing activities will be sufficient to assure the continued existence of Pacific herring.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.
- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.
- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).
- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of Pacific herring populations is linked with the addition and restoration of tidal habitats, Delta outflow, and the aquatic food web within and upstream of San Francisco Bay.

OBJECTIVE, TARGETS, AND ACTIONS

The Strategic Objective is to enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

SPECIES TARGET: Increase abundance of marine/estuarine fish and large invertebrates, particularly in dry years.

LONG-TERM OBJECTIVE: Maintain a high level of harvest management that will allow for sustainable fisheries for Pacific herring and their roe.

SHORT-TERM OBJECTIVE: Continue, with caution, the present limited-entry fishery and determine the major factors that limit both the fishery and herring spawning in San Francisco Bay.

RATIONALE: Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.

STAGE 1 EXPECTATIONS: In the next 7-10 years the fishery will have continued at roughly present levels and investigations continued to determine factors limiting herring abundance and spawning success, especially as tied to Bay-Delta physical processes.

RESTORATION ACTIONS

Pacific herring would benefit from the following restoration activities and actions:

- Limit further introductions of non-native species especially from ship ballast water.
- Restoration of tidal and shallow-water habitat in the Suisun Marsh and San Francisco Bay
- More uniform salinity regimes in the San Francisco Bay during both drought and wet water years.

REFERENCES

Department of Fish and Game. 1998. Final Environmental Documentation for Pacific Herring Commercial Fishing Regulations.

Strategic Plan for Ecosystem Restoration. 2000. CALFED Bay-Delta Program, Programmatic EIS/EIR Technical Appendix. July 2000.

Wang, Johnson, C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. IESP Technical Report 9. pps 3-4 through 3-7.

◆ GRASS SHRIMP

INTRODUCTION

The term "grass shrimp" refers collectively to two genus of shrimp (*Crangon and Palaemon*) that are present in the San Francisco Bay. These grass shrimp are commercially fished in the Bay and sold as bait. Early this century, commercial trawls landed around three million pounds of shrimp for a dried shrimp market. Recently, catches of shrimp have been between 100,00 to 200,000 pounds of shrimp per year. The general life cycle of these shrimp is to hatch larval shrimp in highly saline areas and the juveniles migrate to less saline areas to mature. These shrimp are relatively short lived and mature in about one year.

A factor that may limit the grass shrimp's ability to contribute to a healthy ecosystem is a reduction in freshwater outflow.

RESOURCE DESCRIPTION

The genus *Crangon* is comprised of three native species (*C. franciscorum*, *C. nigricauda*, and *C. nigromaculata*) while the genus *Palaemon* is a single introduced species (*P. macrodactylus*). Unlike the *P. macrodactylus*, which remains in the Bay throughout its life cycle, *Crangon spp.* utilize the Bay as a nursery area and move into less saline waters to mature. *C. franciscorum* juveniles are most abundant in April through May in brackish warm waters. *C. nigricauda* juveniles peak in late-spring to early summer in higher saline waters. *C. nigromaculata* juveniles occur from May through November with all ages occurring in cool shallow coastal waters. *P. macrodactylus* larvae hatch from April to August and juveniles are abundant from June to September.

VISION

The vision for grass shrimp is to maintain self-sustaining populations in order to support existing commercial fisheries.

A major focus of efforts will be to assure that average March through May outflow from the Sacramento and San Joaquin rivers is above 30,000 cfs. Many of the actions described in the Stage 1 Actions may not benefit these species. However, other CALFED actions will benefit these species such as levee improvements that will prevent the influx of more saline waters into the western Delta.

Efforts will need to be implemented that look at the interaction among members of the benthic community. Specifically the interaction between grass shrimp and the recently introduced mitten crab (*Eriocheir sinensis)* will need to be examined.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain a sustained population of grass shrimp in the Sacramento and San Joaquin rivers and Delta would also involve cooperation and support from other established programs.

- Water Quality Control Program for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995).
- California Fish and Game Commission will continue to regulate and develop fishing regulation based on recommendations by the California Department of Fish and Game.
- Suisun Marsh Preservation Agreement between the Department of Fish and Game, Department of Water Resources, U.S. Bureau of Reclamation, and Suisun Resource Conservation District.